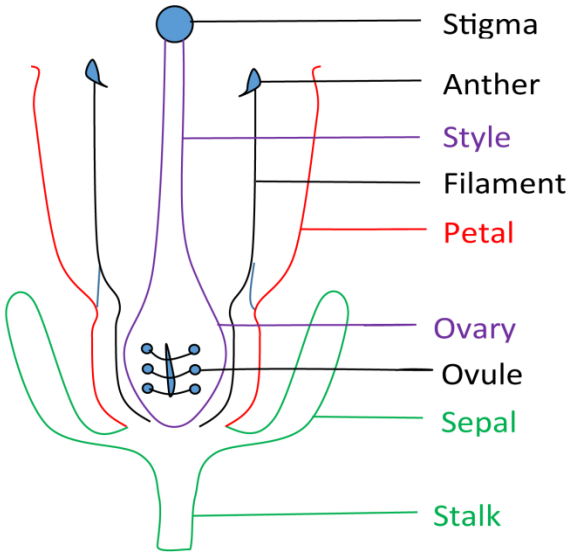
Sexual reproduction in plants

The flower

The flower is the sexual reproducing organ of the flowering plants. It is divided into 3 parts

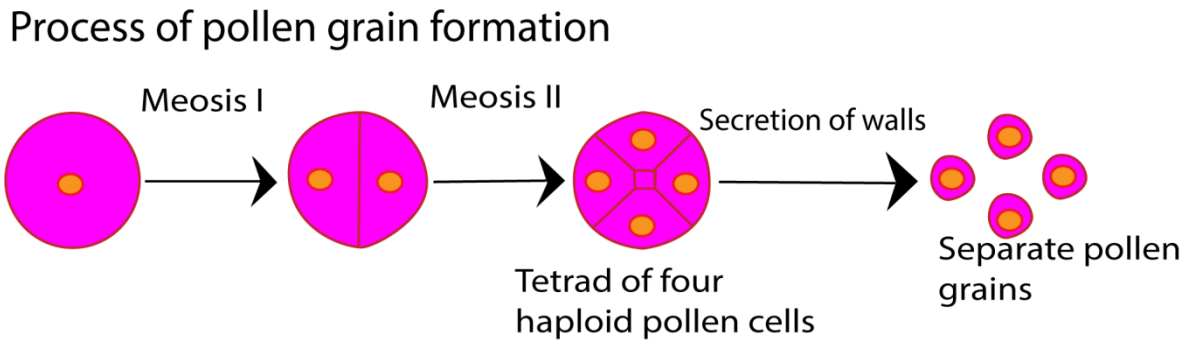
1. Perianth: these surround the male and female parts of the flower. It consists of whorls. The outer whorl is made of sepals collectively known as the calyx. The inner whorl is made of petals – collectively known as corolla. Corolla is brightly coloured and scented to attract insect pollinators.

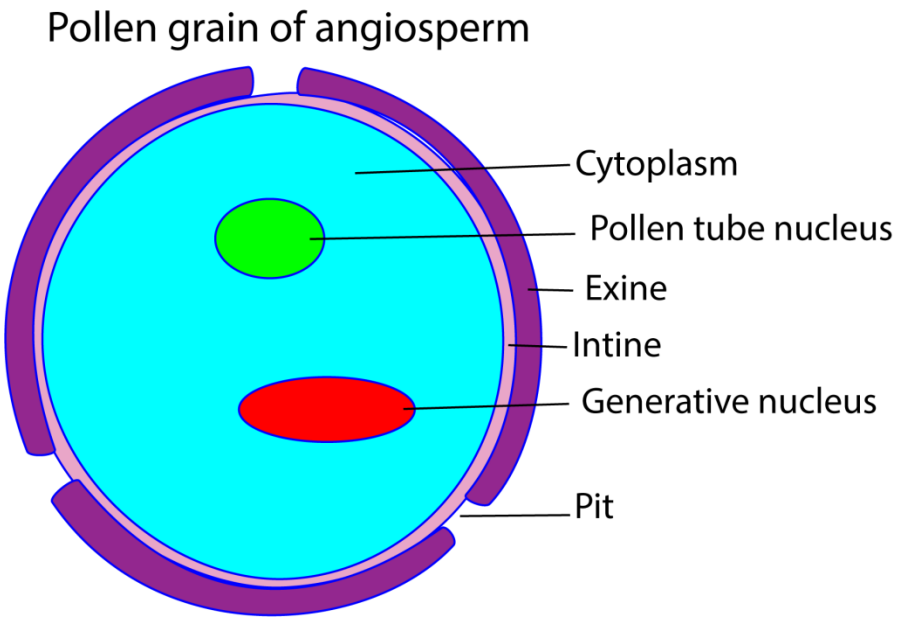
   Diagram of a typical flower



2. **Androecium (Microsprophyte)**
   This is the male sex organ in flowers. It produces the pollen grain. Each androecium consists of a filament (a stick portion) and an anther (knoblike enlarged structure) that produces pollen grain.

   Development of pollen grains
   The anther contains pollen sacs that contain spore mother cells. Each spore mother cell undergoes meiosis to form pollen grains as shown below.





Immediately after meiosis, the young pollen grains are seen as tetrad. Each grain develops a thick cuticle.

3. Gynoecium (megasporophte)
   Consists of a stigma, style and ovary. The Stigma has a receptor surface and found at the tip of the style. Pollen grains adhere to the surface onto sticky, sugary substance secreted by the stigma. The ovary is found at the base of the style and contains ovules.

Formation of female gametes

The formation of female gametes takes place in the ovary. The ovary is hollow and contains one or more ovules. The ovule starts as a small bulge of tissue called **nucellus** on the inside of the ovary wall. Two folds of tissue called **integuments** grow up and over the nucellus leaving a small pore, the micropyle, at the end.

The ovule is megasporangium. Inside it a single cell (embryo sac mother cell) undergoes meiotic cell division to form a row of four haploid cells (megaspore). Three of these cells usually disintegrate. The remaining one expands and its nucleus undergoes three successive mitotic cell division to form an immature embryo sac containing eight nuclei which become arranged in 3:2:3 pattern. Three remain at the micropylar end where they become separated from each other by cell walls and form one egg cell and two similar helpers or **synergid** cells. The three at the other end become antipodal cells. The remaining two nuclei occupy a central position and do not become surrounded by cell walls. They are called **polar nuclei**. The mature sac is surrounded by the ovule and the ovary.

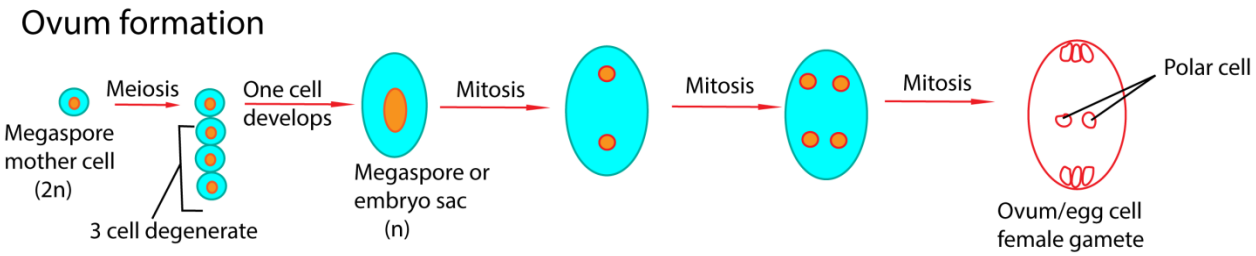
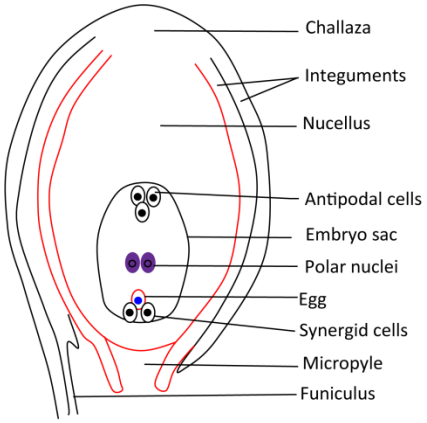


Diagram of an ovule



Functions of parts ovary

- Stalk/funiculus allows passage of food and water to the growing ovary
- Ovary wall protects the ovule
- Egg cell develop into seed
- Embryo sac protects the embryo
- Integument protect the embryo and develop into seed coat
- Micropyle allow entry of pollen nuclei.

Pollination
This is the transfer of pollen grains from an anther to the stigma.

Self-pollination is the transfer of pollen grains from the anther to the stigma of the same flower or another flower of the same plant.

Cross pollination is the transfer of pollen grains from the anther of one flower to the stigma of another flower on a different plant of the same species.

Development after pollination
As soon as a mature pollen grain fall on a receptive stigma. The pollen grain then absorbs the sugary fluid and increase in size and volume. The exine burst open and the entine grows into a long narrow tube called the pollen tube. The pollen tube nucleus occupies the position at the tip and controls it growth. The generative nucleus again divides mitotically into 2 male nuclei. On reaching the ovary the pollen tube enters, usually through the micropyle to the embryo. One male nucleus fuses with egg cell to forma diploid zygote. The second male nucleus fuse with both polar nuclei to form a triploid nucleus which give rise to **endosperm**. The endosperm in cereals is where food reserves are stored. In seed of other plants (dicotyledonous plants) endosperm is absorbed by the developing cotyledon which then provides the main food reserve.

Plants are therefore said to undergo **double fertilisation** because two male nuclei fuse within the ovum; one with the egg cell to form a zygote while another with the polar two polar cells to form an endosperm.

After fertilization

1. The zygote divides mitotically, growing and developing into the embryo. The embryo consists of a radicle (young root) plumule (young shoot) and either on cotyledon or two cotyledons (seed leaves). The embryo is attached to the wall of the expanding embryo sac by a suspensor which acts as passage of food to the embryo.
2. The primary endosperm nucleus (triploid) divides into a mass of nuclei which are separated from one another by thin cell walls. It becomes food storage for the seed.
3. The ovule develops into the seed. The integuments of the ovule become the seed coats. The outer integument is called the Testa while the inner is called tegmen. Bothe of these layers are tough and protective.
4. The ovary develops into a fruit.

Parthenogenesis
This is the development of a new offspring from unfertilised egg. Haploid parthenogenesis, the egg is produced by meiosis whereas in diploid parthenogenesis the egg is produced by mitosis; e.g. production of wingless aphids.

Parthenocarpy
This is the development of a fruit without fertilization such fruits cart be artificially produced for commercial purpose by spraying with auxins.

Cross and self-fertilization

1. Self-fertilization is the union of gametes from the same individual flower.

Advantage:

a. it increases the chances of fertilization and formation of new organism.

b. only one parent is required, and that beneficial qualities are more likely to be passed on to the offspring since all offspring are genetically identical to the parent.

Disadvantage:

a. it reduces genetic variability, so the organism will be less adapted to changes in the environment.
b. It may transfer diseases to the offspring

2. Cross fertilization: is the union of gametes from the different individual or flower of the same species. This brings in genetic mixing and genetic variability which increase the hybrid vigour.

Advantages of sexual reproduction
- Genetic mixing
- Seeds can go through adverse conditions in a dormant stage.
- Allow genetic improvement.

Means employed by plants to limit self-fertilization in plants

(a) Dichogamy: anthers mature and stigma become receptive at different times
  (i) Protandry: anther mature before the stigma
  (ii) Protogyny: stigma mature before the anther
(b) Self-incompatibility: the pollen grain fails to develop on the stigma of the same flower.
(c) Special floral structure: most hermaphrodite flowers have structural features that favour cross pollination; e.g. stigma may be above the anthers thus removing the possibility of pollen falling on the stigma of the same flower. Other have nectar and good scent to attract pollinator.
(d) Inflorescence: having many flowers in close proximity on the same stalk favours cross pollination.

(e) Some plants have monoecious flower, i.e. separate male and female flowers on the same plant. e.g. maize and coconut.
(f) Some plants are **dioecious**, separate male and female flower of different plants. Despite the advantage of cross fertilization, dioecious plants are not many because only half of the plants are able to produce seeds and there is waste of pollen grains in wind dispersal.

Adaptations promoting self-fertilization

1. Bisexual, hermaphrodite flowers e.g. marigold.
2. Anther and stigma ripen at the same time. E.g. tomato.
3. Flowers remain enclosed until fertilization has taken place. E.g. garden pea
4. The flowers are buried in ground e.g. G. nuts.

Advantages and disadvantages of reproduction by seed

Advantages

1. The plant is independent of water for sexual reproduction and therefore better adapted for land environment.
2. The seed protects the embryo
3. The seed contains food for embryo either in cotyledon or in endosperm
4. The seed is adapted for dispersal
5. The seed remain dormant and survive adverse condition
6. The seed as a product of sexual reproduction has advantages genetic variation

Disadvantage

1. Seeds are relatively large structure because of extensive food reserves which makes dispersal more difficult than spores
2. Seeds are often eaten by animals for their food reserves.
3. There is reliance on external agent such as wind, insects and water for pollination which is a risk
4. There is large wastage of seed because the chances of survival of a given seed are limited
5. The food supply in a seed is limited as compared to vegetative reproduction
6. Two individuals are required in dioecious species making the process risky than reproduction in which only one parent is involved.

Similarities between sexual reproduction in flowering plants and animal

(i) Gamete formation
- Start from germ cells/unfertilised sell
- Gamete formation is by meiosis
- More than one male gamete is formed from one germ cell
- Male and female gametes are haploid
- Male gametes are smaller than female gametes

(ii) Gamete transmission
- Male gamete moves towards an ovum by chemical attraction

(iii) Fertilization
- Syngamy (fusion of nuclei) occurs

- Only one male gametes fuse with an ovum to forms single embryo
- Male gametes digest their way through the walls of the ovum

(iv) Development and production
- The embryo is nourished through the same embryo sac
- Offspring show variation from the parents

Differences between sexual reproduction in flowering plants and animal

(i) Most animals are dioecious because there is less risk of transferring the gametes as a result locomotion, internal fertilization and behaviour patterns such as courtship whereas most plants are monoecious

(ii) In plants, reproductive organs are temporary but in animals are permanent and function throughout their lives

(iii) In plants male gamete require an agent whereas in animals there is copulation

(iv) In plants, male gamete reach ova by developing tubes, but male gametes in animals are motile.

(v) In plants double fertilization occurs which does not occur in single animals

Fruits and seed dispersal

This is the scattering of seed and fruits from the parent.

Why dispersal?

1. To avoid overcrowding
2. To increase the distribution of plants so that they can colonise better places
3. To preserve species by spreading them and preventing them from extermination by natural hazard e.g. fire.

Dispersal agent

1. Wind

Fruits and seed dispersal by wind have the following features.
- They are small and light
- They have, flattened wing like structures e.g. Tecoma or a parachute of fine hair e.g. tridax to increase their surface area and air resistance.

2. Animal

Fruits and seed dispersal by animal have the following features
- May have sticky hairs e.g. Desmodium
- May have hooks to stick on fur
- Some fruits have attractive colour, scent and sweet mesocarp when ripe, e.g.
- May have small indigestible seed which are deposited in faeces, e.g. passion fruit.
- Some plants have seed enclosed in woody endosperm that cannot be chewed, e.g. mango

3. Water

Fruits dispersed by water
- Have floating devices, e.g. the seeds of the water lily have aril, small float, that have in air. The seed can float on water until the aril decays, then it sinks to the bottom and germinate

4. Explosive mechanism of dispersal
   e.g. balsam, bean

Seed Dormancy

Is the state in which a seed that is viable will not germinate even if the conditions that are necessary for germination are provided?

Dormant seed are usually dry, their metabolic activity is much reduced and they respire anaerobically.

Importance of seed dormancy

- Seed are able to withstand adverse external conditions such as very cold or very dry whether.
- It allows seed and fruits to disperse

Causes of seed dormancy

The main factors that causes the seed dormancy are:

1. **Seed coats impermeable to water**: The seed of certain family have very hard seed coats which are impermeable to water. This dormancy remains until the testa layer decay by soil **microorganisms**. The impermeable seed coats are found in the family **leguminosae, Malvaceae, convolvulaceae.**
2. **Seed coat impermeable to oxygen**: This type of dormancy is because of the **impermeability of the seed coats to oxygen**. But later seeds become more permeable to oxygen so that it germinates afterwards. This type of dormancy in found in the **family compositae.**
3. **Mechanically resistant seed coat**: In certain **seeds of weeds have hard seed coats** that prevent the expansion of embryo.
4. **Immaturity of the embryo:** In the seeds of plants like **the Orchids, Ginkgo** etc. The immaturity of the embryo is due to the **failure of the embryo to develop** when the seeds are shed.
5. **Due to the effect of germination inhibitors**: The inhibition caused due to the presence of the **inhibitor substances in the seed coat, endosperm, embryo or any structure**. Some of the important germination inhibitors are; **Coumarin, Phythalids, Ferulic acid, Abscisic acid, Dehydracetic acid and parasorbic acid.**

6. **Low temperature:** In certain plants the seeds **remain dormant after harvest because they require low temperature for germination.** The seeds germinate in the spring season.
7. **Light sensitive seeds:** In certain seed the germination is affected by the light so the absence of light results in the seed dormancy. These seeds which are **sensitive to sunlight** are termed as the **photoblastic seeds**, where as in some other seeds the light inhibits the seed germination so they are **negatively photoblastic.**

Various methods have been used by seed scientist and technologists to break the dormancy of seed.

Simple and widely used methods are

A. Scarification:

Any treatment i.e. physical or chemical that weakness the seed coat, is known as scarification.

Scarification method is applied, when dormancy is imposed by hard seen coat e. g. in legumes-cajanus cajan, (tur), gram etc.

In this method there are various way to break hard seed coat such as:

1. Seeds are either rubbed on a sand paper manually. At the time of rubbing care should be taken that not to damage the axis of the seed e.g. Green gram & subabool.
2. When seed coat is too hard i.e. of woody nature, the seed coat has to be removing completely by breaking it. E.g. Rubber (Havea app) seed India teak wood seed.
3. Soaking treatment: Soaking hard seed coat in concentrated or diluted solution of sulphuric acid for 1 to 60 minutes, it removes seed coat impermeability. E. g. cotton seeds, India teak wood seeds etc.

B. Temperature Treatments:

1. When the dormancy is due to embryo factor i.e. the seed is incubating at low temp. (0- 5o C) over a substratum for 3 to 10 days placing it at optimum temp. Required for germination. E.g. mustard. – (Brassica campestrits)

2. Some seeds required a brief period of incubation (from a few hours to one to five days) at 40 to 50^0 C before germinating at required temp. (in this method care should be taken that moisture content of the seed is not more than 15% e.g. paddy (Oryza Sativa)
3. Hot water treatment is also an effective method of breaking hard- seed ness in legumes. In this method the seeds are soaked in water at 80oC temp. For 1 – 5 minutes (depending up on the type of seed) before putting for germination.

C. Light Treatments:

Same seeds do not germinate in dark thus it provides continuous or periodic exposure of light is essential e. g. Lettuce (Lactuca Sativa) required red light (660nm) or white light is essential for germination to occur.

D. Treatments with growth regulators & other Chemicals:

Endogenous dormancy may be due to presence of germination inhibitors. Application of low level of growth regulators (i.e. Gibberellins, Cytokinins and Ethylene etc) may break the seed dormancy.

Most widely used growth regulators are gibberellins and kinetics e.g. seeds of sorghum crop presoaking seed treatment with GA3 at the conc. Of 100 ppm have been used for breaking seed dormancy

Among other chemicals potassium nitrate (0.2%) and thio – urea (0.5 to 3%) are widely used for breaking seed dormancy in oat (Avena Sativa), barley (Hordeum vulgare), tomato (Lycopersicon spp).

(For prepare 100 ppm solution of GA3, weigh 100 mg of GA3 & dissolve in a few drops of alcohol and make up the final volume (1000 ml) by adding distilled water).

(50 ppm kinetin 5 mg dissolved in few drops of alkaline made with sodium hydroxide and makes the final volume 100ml it gives to final conc. Of 50 ppm)

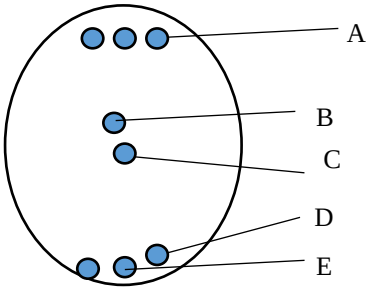
Exercise
Objective questions

1. Which of the following is the mother cell from which the ova are developed?
   A. Oogonium
   B. Primary oocyte
   C. Primordial germ cell
   D. Secondary oocytes
2. Some sporophytes contain a mixture of haploid, diploid and triploid cells at some point. This condition only occurs in
   A. Flowering plants
   B. Mosses
   C. Ferns
   D. Conifers
3. A plant species where 2n = 12, the chromosome number in its endosperm after fertilization is
   A. 6
   B. 12
   C. 18
   D. 24
4. Which of the following statements is not correct about seed dormancy?
   A. It allows further development of the seed
   B. It is induced by internal factors
   C. It increases the chance of survival of seed
   D. It is ended by external factors

5. Dioecious plants are rare in spite of having the advantage of cross pollination because
   A. Anther and stigma mature at different times
   B. The male and female plants are usually apart
   C. Half of individual do not produce seeds
   D. Only few agents of dispersal are involved

6. Which one of the following is an essential feature for successful terrestrial life of flowering plants?
   A. reduction of gametophyte to spores
   B. development of pollen tube to transfer male gametes
   C. possession of well-developed vascular system
   D. reduction of sporophyte to seed
7. Which one of the following may sporophyte contain haploid, diploid and triploid cells at some stage?
   A. Conifers
   B. Mosses
   C. Flowering plants
   D. Ferns

The figure shows an ovule of a flowering plant



8. A triploid nucleus is formed by fusion of a male nucleus with
   A. D and C
   B. B and C
   C. A and B
   D. D and E

9. Which of the following is a difference between flowers of dicotyledonous plant and those of monocotyledonous plant? Flowers of dicotyledonous plant usually
   A. Lack sepals
   B. Possess superior ovaries
   C. Bear floral parts in groups of 4s and 5s
   D. Possess fused petals

10. During fertilization in plants, the
   A. Vegetative nucleus fuses with the pollen nucleus
   B. Generative nucleus fuses with the egg nucleus
   C. Vegetative nucleus fuses with the egg nucleus
   D. Vegetative nucleus fuses with the antipodal cell nucleus

11. Which one of the following maintains the highest level of genetic uniformity?
   A. Interbreeding
   B. Selective breeding
   C. Random breading
   D. Inbreeding

12. Double fertilization is said to occur in some plants because
   A. One male nucleus fertilizes two polar nuclei
   B. Two fusions occur in an embryo sac
   C. One egg cell is fertilized by two male nuclei
   D. Two male nuclei fuse with an antipodal cell

13. Which one of the following characteristics of a flower would encourage most variation of the offspring after fertilization?
    A. Stigma higher than anthers
    B. Stamen and pistil mature at the same time
    C. Flower remain closed for some time when mature
    D. Plant's pollen can germinate on its own stigma
14. Which one of the following is true of diploid parthenogenesis? The egg is formed by
    A. Meiosis and develop without fertilization
    B. Mitosis and develop after fertilization
    C. Meiosis and develop after fertilisation
    D. Mitosis and develop without fertilisation
15. In flowering plants, the number of chromosomes in the structure which gives rise to the embryo sac are
    A. n
    B. 2n
    C. 3n
    D. 4n

16. Which of the following is true of diploid parthenogenesis? The eggs are formed by
    A. Meiosis and develop without being fertilized
    B. Mitosis and develop after fertilisation
    C. Meiosis and develop after fertilisation
    D. Mitosis and develop without being fertilised
17. Which one of the following is true during fertilisation in higher plants?
    A. One of the male nuclei fuses with polar nuclei
    B. Two of the cells at the micropyle become non-functional
    C. The antipodal cells fuse with one male nuclei
    D. All the polar cells are fertilized

18. Which of the following conditions may limit the chances of variation in offspring of flowering plants?
    A. Dioecism
    B. Self-incompatibility
    C. Protandry
    D. Hermaphroditism

19. The sporophyte generation of flowering plants has a mixture of cells with different nucleic acid contents because
    A. Of chromosomal mutation
    B. They produce megaspores and microspore
    C. Of double fertilisation
    D. The flowers produce fruits and seeds.

20. Hermaphrodite carry out cross pollination in order to
    A. Encourage variation
    B. Encourage rapid development of eggs
    C. Produce more off springs
    D. Encourage association among individual

21. A generative nucleus in a pollen grain serve to
    A. Fuse with the egg cell to form a zygote
    B. Control the growth of the pollen tube
    C. Produce two male nuclei
    D. Fuse with the polar nucleus to form the triple endosperm nucleus
22. One evolutionary advantage of sexual reproduction over asexual reproduction is
    A. formation of diploid gametes
    B. a reduced potential for variation
    C. development of specialised somatic tissue
    D. an increased potential for variation
23. Double fertilization in flowering plants refers to the fusion of two male nuclei with
    A. Antipodal nuclei and polar nuclei
    B. Egg nucleus and polar nuclei
    C. Egg nucleus and antipodal nuclei
    D. Two egg nuclei
24. Which one of the following plants develop without fertilization?
    A. Paw paw
    B. Red pepper
    C. Pine apple
    D. lemon
25. One evolutionary advantage of sexual reproduction over asexual reproduction is
    A. formation of diploid gametes
    B. a reduced potential for variation
    C. development of specialised somatic tissue
    D. an increased potential for variation
26. Dioecious plants are rare in spite of the advantages of cross pollination because
    A. Anthers and stigma mature at different times
    B. The male and female plants are usually apart
    C. Half of the individual do not produce seeds
    D. Only few agents of dispersal are involved

27. A biological advantage of a monoecious condition is that
    A. Many offspring result from each fertilization
    B. Every individual is capable of producing offspring
    C. Self-fertilization is encouraged
    D. Male and female gametes mature at the same time

28. Which one of the following plants develop without fertilization?
    A. pawpaw
    B. red paper
    C. lemon
    D. pineapple
29. Some sporophytes contain a mixture of haploid, diploid and triploid cells at some point. This condition only occurs in
    A. flowering plants.
    B. mosses.
    C. ferns.
    D. Conifers
30. Dioecious plants are rare because
    A. They have separate male and female flowers on the same plant.
    B. There is self-incompatibility of gametes
    C. The male and female plants are rarely mature at the same time
    D. Part of each species of dioecious plants does not bear fruits

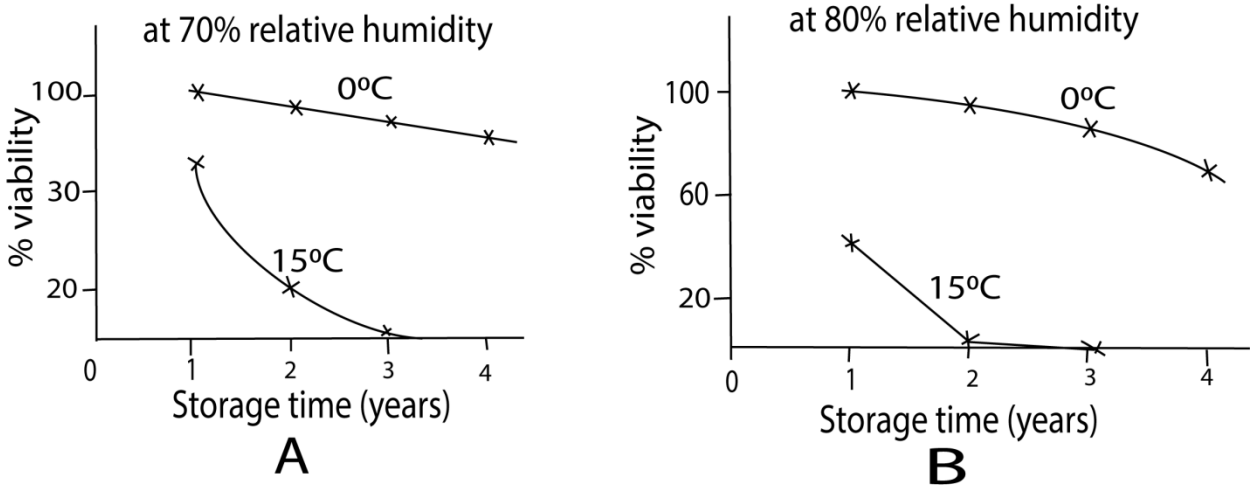
31. The following can result in some variation of the offspring except

    A. Haploid parthenogenesis. B. Conjugation.

    C. Fragmentation. D. Self-fertilize

Structured questions

32. Figure A and B below show viability of fescue grass seed at different conditions.



(a) From the figured state the factor that affect viability of fescue grass seed (1 ½ marks)
(b) Describe the effect of each factor in (a) on the viability of seeds (03marks)
(c) Explain the effect of each factor in (a) on viability of seeds (5 ½ marks)

33. (a) Distinguish between dormancy and hibernation.
(b) List down the causes of dormancy

(c) Explain the advantages of seed dormancy

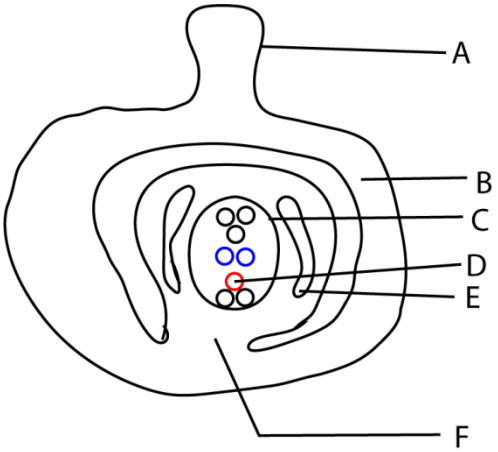
(d) suggest three ways of breaking seed dormancy.

34. (a) Give ecological importance of each of the following structural arrangement in plants
(i) Monoecious

(ii) Dioecious
(b) Explain why
(i) In dioecious plants, male plants are usually associated with dry soils while female plants are associated with moist soil is (02marks)

(ii) Nearly all dioecious plants are wind pollinated (2mark)
(c) Give one reason why dioecious plants are rarer than monoecious plant (2marks)

35. The figure below represents a section through the ovary of flower



(a) (i) Name structure labelled A, B, C, D, E and F
(ii) State the functions of each of the parts labelled
(b) In the space below draw the diagram of the structure of pollen grain
(c) Explain what is meant by double fertilization

Assay questions

36. (a) Describe the process of fertilization in higher plants
(b) Outline the events which tape place after fertilization

37. (a)What is meant by double fertilization in flowering plants? (4marks)
(b) Explain how:
(i) asexual reproduction produces offspring identical to the parent (4marks)

(ii) sexual reproduction cause variation among offspring. (5marks)

(c) Under what circumstances may variation

(i) occur in asexually produced individuals (3marks)

(ii) not occur in sexually produced individuals (04marks)

38 (a) Outline the events that lead to the formation of pollen grain in flowering plants. (7marks)

(b) How does the development of Embryo sac in flowering plants differ from oogenesis in humans? (4marks)

(c) Give an outline of the life cycle of a named pteridophyte. (09marks)

39 (a) What is the effects of inbreeding in a population? (02marks)

(b) Describe the mechanism which limit inbreeding in plant (10marks)

(c) How does meiosis contribute to variation? (08marks)

40. Some viable seeds are not able to germinate immediately they are dispersed from their parent plant even when all necessary for conditions for germination are provided. Discuss

41. The use of seed and other planting materials are common methods in plant propagation. Using named examples, give the advantages and disadvantages of each method

43. (a) Describe mechanisms which promote out-breeding in monoecious m plants. (12marks)

(b) Explain how sexual reproduction cause variations (8marks)

44. (a) Explain what is meant by dormancy in seeds. (02marks)

(b) Describe the causes of dormancy

(c) Explain why dormancy is more common in weeds than in tropical forest trees (08marks)

Answers to objective

1.	D	11.	D	21	C	31	C		
2.	A	12.	B	22.	D				
3.	C	13.	A	23.	B				
4.	D	14.	D	24.	C				
5.	C	15.	A	25.	D				
6.	B	16.	D	26.	C				
7.	C	17.	A	27.	B				
8.	B	18.	D	28.	D				
9.	C	19.	C	29.	A				
10.	B	20.	A	30.	D				

32. (a) humidity
Temperature
Storage time

(b) the higher the humidity the faster the seeds lose viability
The higher the temperature the faster the seeds lose viability
The longer the seeds are stored, higher they lose viability

(c) high humidity lead to loss of seed viability because it promotes growth of moulds, infections and pests.

High temperature lead to loss of viability it increases respiration and exhaustion food reserve. It also promotes moulds and pests.

The longer the seed are stored, the more they lose viability due to increase in damage by pest and moulds.

33(a) differences between dormancy and hibernation
Dormancy is a period of halted growth while hibernation is a period of reduced metabolic activity of an organism

Dormancy occurs in seeds, spores while hibernation occurs in small animals

(b) cause of dormancy
- immaturity of the embryo of a seed
- presence of germination inhibitor
- impermeable hard seed coat

(c) advantages of seed dormancy
- allows time for seed dispersal
- enable plant to withstand unfavourable conditions
- allows time for an embryo to mature

(d) – breaking the seed coat
- Stratification/subjecting the seeds to an obligatory period of cold
- removal of germination inhibitors through soaking of seeds

34. Solution

(a) (i) – increases chances of pollination and reproduction

- increases chances of habitat colonization following easy pollination.

(ii) Increases chances of genetic variation among offspring with increased chances of colonization of habitat in different ecosystem.

(b) (i) – Male plants must produce large quantities of light and dry pollen grains which must land and quickly germinate on moist stigmas.

- being in dry soil reduces the general water content of the plant and allows the pollen grains to dry easily.
- the female plants are found in moist soils in order to increase the water content to ensure that the stigma is moist and sticky. When the pollen grain land on it quickly germinate

(ii) The opposite sexual reproductive structure usually occurs on different plants yet pollen grains are usually produced in large amounts.

- Wind pollination increases the chance of fertilization

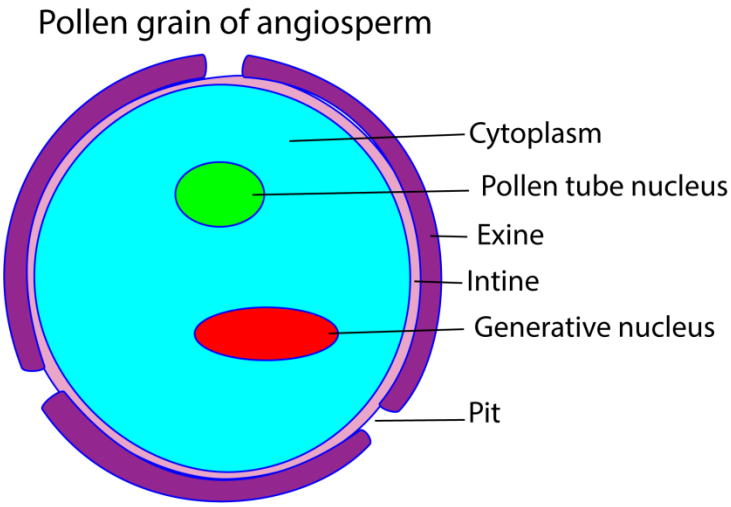
(c) The chance of pollination and reproduction are limited as they are usually depend on wind for pollination

- Only half of the plants produce seeds

35. (a) (i) A - style
B – ovary
C – Embryo sac
D – ovum/egg cell
E – integument
F – micropyle

(ii) Usage of parts
A – allows passage of pollen grain
B – protects inner parts
C – protects female gametes
D – Develops into seeds
E – Develops into the seed coat
F – allows entrance of pollen tube/grain

(b)



(c) **Double fertilization** involves two pollen cells; one fertilizes the egg cell to form the zygote, while the other fuses with the two polar nuclei that form the endosperm.

36. (a) Fertilization is the fusion of male and female to produce a zygote

(i) In higher plants, the male gamete is the pollen grain produced by anthers while the female gamete the ovum resides in embryo sac in the ovary where fertilization occurs

(ii) When a pollen grain lands on the receptive stigma, the pollen grain then absorbs the sugary fluid and increase in size and volume.

(iii) The exine burst open and the intine grows into a long narrow tube called the pollen tube.

(iv) The pollen tube nucleus occupies the position at the tip and controls it growth.

(v) The generative nucleus again divides mitotically into 2 male nuclei.

(vi) On reaching the ovary the pollen tube enters, usually through the micropyle to the embryo.

(vii) One male nucleus fuses with egg cell to forma diploid zygote.

(viii) The second male nucleus fuse with both polar nuclei to form a triploid nucleus which give rise to **endosperm**.

After fertilization

(i) The zygote divides mitotically, growing and developing into the embryo. The embryo consists of a radicle (young root) plumule (young shoot) and either on cotyledon or two cotyledons (seed leaves). The embryo is attached to the wall of the expanding embryo sac by a suspensor which acts as passage of food to the embryo.

(ii) The primary endosperm nucleus (triploid) divides into a mass of nuclei which are separated from one another by thin cell walls. It becomes food storage for the seed.
(iii) The ovule develops into the seed. The integuments of the ovule become the seed coats. The outer integument is called the Testa while the inner is called tegmen. Bothe of these layers are tough and protective.
(iv) The ovary develops into a fruit.

37. Solution

(a) Double fertilization refers to occurrence two independent nuclear fusions during fertilization in the embryo sac of flowering plants.

During this process, two male nuclei are involved; one fuses with functional egg cell to form a diploid zygote; the other fuses with both polar nuclei to form a triploid nucleus, the primary endosperm nucleus.

(b) (i)Asexual reproduces offspring identical to the parent because it occurs by mitosis. During this process, the daughter cells produced always have the same genetic constitution as their parent cells. As such, the organisms produced by mitosis (asexual reproduction) also have the same constitution as their parents and are therefore identical to them.

(iii) Variation in sexual reproduction is caused

- Production of unique gametes by crossing over between homologous chromosomes separates linked gene at metaphase I of meiotic division.
- When the homologous pairs of chromosomes line up in metaphase I, each pair lines up independently from the other pairs.
- A third source of genetic diversity occurs during meiosis II, in which the sister chromatids separate and are randomly distributed to the daughter cells, the gametes. Crossing over in meiosis I leads to non-identical chromatids in meiosis II chromosomes
- Fertilization creates genetic diversity by allowing each parent to randomly contribute a unique set of genes to a zygote.

(c) (i) Asexually produced individuals are usually identical; however, variations may occur under the following circumstance.

- When random mutations occur among the different individuals, causing alteration of their genetic constitution, it leads to production of offspring with such variations in subsequent generations.
- When the environment imposes certain phenotypic variations on the different individuals such individuals although they have the same genetic constitution, show phenotypic which are not however transmitted to subsequent generations.

(ii) Sexually produced individuals usually show variation, however, variations may not occur under the following circumstances.

- When fertilization occurs between closely related individuals, the offspring produced may not show much variation.
- When crossing over does not occur during meiosis when the gametes are formed fusion of the gametes produces offspring identical to the parents.
- In hermaphrodism, only one parent is parent is involved and therefore there is not much variation

38. Solution

(a) This question requires that you describe what happens in the anthers during formation of pollen grains from the meristematic cells to mature pollen grains. However, you should start by indication where in the plant, this process occurs.

Pollen grains are formed from meristematic cells in pollen sacs of the anthers.

In infancy, each pollen sac consists of a homogenous mass of meristematic cells.

During development, these cells differentiate into four layers of cells. The central layer called the **sporogenous** layer divides to produce a number of microspores, also called pollen mother cells.

Pollen mother cells divide by meiosis and each produces four haploid cells.

Each haploid cell develops a tough productive wall around itself and becomes a pollen grain.

Complete maturation involves mitotic division of the haploid nucleus inside the pollen grain to form two haploid nuclei of unequal size. The larger is called the generative nucleus and smaller is the pollen tube nucleus.

(b) In this question you should compare the events that occur during either process up to or including the products of each process.

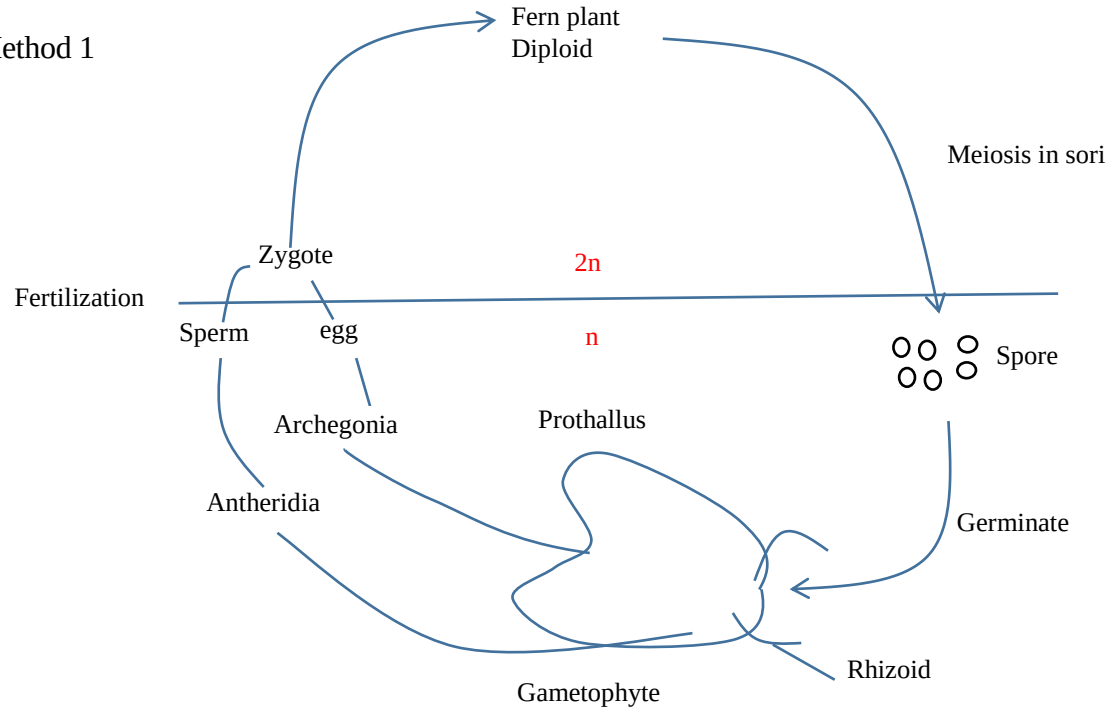
Development of embryo sac	Oogenesis
1. Develops primarily by mitosis from dedicated haploid functional mega spore cells.	1. Development involves meiotic and mitotic divisions of diploid germ cells.
2. Results in a cell with 8 nuclei	2. Results in a mature egg cell with only one nucleus.
3. No polar cells are formed	3 Polar cells are formed but atrophy (degenerate)
4. No yolk sac is formed	4. A yolk sac is formed.

(c). In this questions, you should state the example of a pteridophyte and then outline its life cycle.

A fern is an example of a pteridophyte.

The life cycle of a fern alternates between two generations; a diploid sporophyte which is dominant and a haploid gametophyte generation as shown;

Method 1



Method 2;

- The gametophyte (prothallus) bears special gamete-forming organs; antheridia which produce sperms (antheroziods) and archegonia which produce eggs (oosphere). From these structures, the gametes are formed by mitosis.
- Sperm (antheroziods) are released from the antheridia and brought into contact with the eggs(oosphere) by swimming) towards the archegonium. The antherozoid and oosphere fuse to form a diploid zygote which grows into a sporophyte.
- The sporophyte is a self-supporting plant bearing specialized structures in which they are scattered over as wide an area as possible.
- The spores then germinate into a gametophyte. This is a flat plate of photosynthetic cells anchored by simple hair-like rhizoids to the soil. The gametophytes then repeat the cycle.

39. **(a) Examples of defects seen with inbreeding include:**

- Reduced fertility.
- Reduced birth rate.
- Higher infant and child mortality.
- Smaller adult size.
- Reduced immune function.
- Increased risk of cardiovascular disease.
- Increased facial asymmetry.
- Increased risk of genetic disorders.

(b) Means employed by plants to limit self-fertilization in plants

(a) Dichogamy: anthers mature and stigma become receptive at different times
  (i) Protandry: anther mature before the stigma
  (ii) Protogyny: stigma mature before the anther

(b) Self-incompatibility: the pollen grain fails to develop on the stigma of the same flower.

(c) Special floral structure: most hermaphrodite flowers have structural features that favour cross pollination; e.g. stigma may be above the anthers thus removing the possibility of pollen falling on the stigma of the same flower. Other have nectar and good scent to attract pollinator.

(d) Inflorescence: having many flowers in close proximity on the same stalk favours cross pollination.

(e) Some plants have monoecious flower, i.e. separate male and female flowers on the same plant. e.g. maize and coconut.

(f) Some plants are **dioecious**, separate male and female flower of different plants.

(c) Contribution of meiosis to variation

- Production of unique gametes by crossing over between homologous chromosomes separates linked gene at metaphase I of meiotic division.
- When the homologous pairs of chromosomes line up in metaphase I, each pair lines up independently from the other pairs.
- A third source of genetic diversity occurs during meiosis II, in which the sister chromatids separate and are randomly distributed to the daughter cells, the gametes. Crossing over in meiosis I leads to non-identical chromatids in meiosis II chromosomes

40.

40. Seed Dormancy

Is the state in which a seed that is viable will not germinate even if the conditions that are necessary for germination are provided?

Dormant seed are usually dry, their metabolic activity is much reduced and they respire anaerobically.

Importance of seed dormancy

- Seed are able to withstand adverse external conditions such as very cold or very dry whether.
- It allows seed and fruits to disperse

Causes of seed dormancy

The main factors that causes the seed dormancy are:

(i) **Seed coats impermeable to water**: The seed of certain family have very hard seed coats which are impermeable to water. This dormancy remains until the testa layer decay by soil **microorganisms**. The impermeable seed coats are found in the family **leguminosae, Malvaceae, convolvulaceae.**

(ii) **Seed coat impermeable to oxygen**: This type of dormancy is because of the **impermeability of the seed coats to oxygen**. But later seeds become more permeable to oxygen so that it germinates afterwards. This type of dormancy in found in the **family compositae.**

(iii) **Mechanically resistant seed coat**: In certain **seeds of weeds have hard seed coats** that prevent the expansion of embryo.

(iv) **Immaturity of the embryo:** In the seeds of plants like **the Orchids, Ginkgo** etc. The immaturity of the embryo is due to the **failure of the embryo to develop** when the seeds are shed.

(v) **Due to the effect of germination inhibitors**: The inhibition caused due to the presence of the **inhibitor substances in the seed coat, endosperm, embryo or any structure**. Some of the important germination inhibitors are; **Coumarin, Phythalids, Ferulic acid, Abscisic acid, Dehydracetic acid and parasorbic acid.**

(vi) Low temperature: In certain plants the seeds **remain dormant after harvest because they require low temperature for germination.** The seeds germinate in the spring season.

(vii) Light sensitive seeds: In certain seed the germination is affected by the light so the absence of light results in the seed dormancy. These seeds which are **sensitive to sunlight** are termed as the **photoblastic seeds**, where as in some other seeds the light inhibits the seed germination so they are **negatively photoblastic.**

Exercise